CO-OPERATIVE RESEARCH AND DEVELOPMENT FOR ADVANCED MATERIALS IN ADVANCED INDUSTRIAL GAS TURBINES

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Microturbine and Industrial Gas Turbine
Peer Review Meeting
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Acknowledgement

- Research sponsored by the U.S. Department of Energy, Under Contract # DE-FC02-00CH11048

- Program Manager: Ms. Jill Jonkouski
  Chicago Operations Office

Key Partners in the program

- Major coating vendors:
  - Turbine Airfoil and Coating Repair (TACR), Middletown, NY
  - Howmet Research Corporation, Whitehall, MI
  - Praxair Surface Technologies
- Major raw materials suppliers
  - Praxair Surface Technologies
  - Transtech Corporation
- Materials Property and coating performance evaluation
  - Oak Ridge National Laboratory
  - University of Cinncinnati
  - Westinghouse Plasma Center
- Host engine customer site for rainbow engine test

Talk Outline

- Program Objectives
- Introduction
  - current TBC limitations and proposed solutions
- Technical approach to incorporate advanced TBC technology into our IGTs
  - a low risk, high pay-off strategy
- Accomplishments to date
  - Optimized deposition trials, key materials properties and component coating trials
- Forward plan to program completion

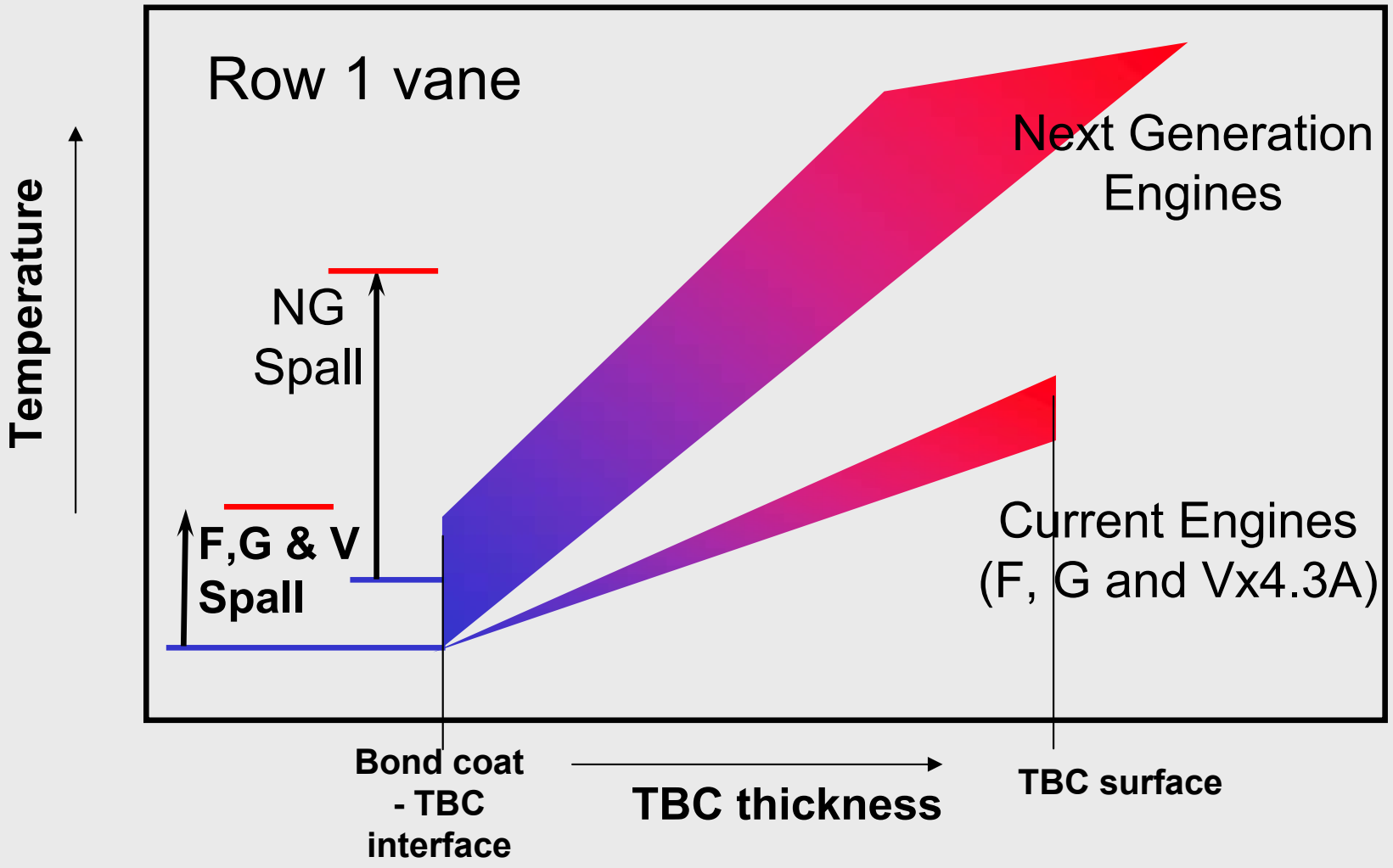
Program objective

A 3-year program, to transition advanced TBC concepts from the development phase to an engine tested coating technology, available for implementation by 12/2003

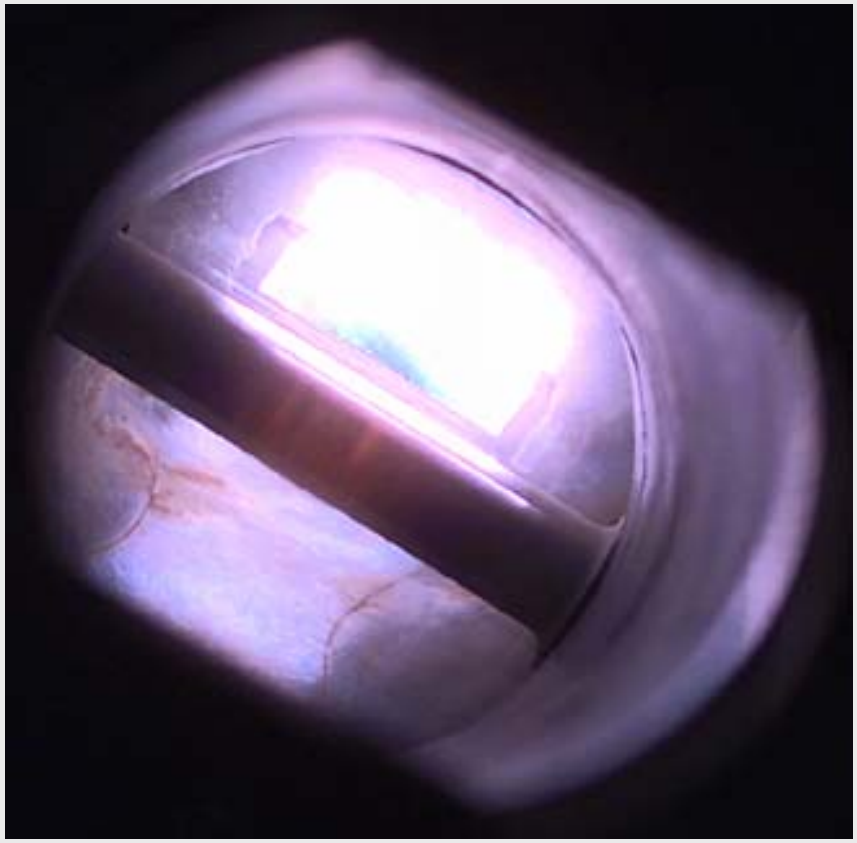
- Increased engine efficiency
- Higher reliability and durability
- Lower electricity cost
- Increased component life
- Reduced emissions

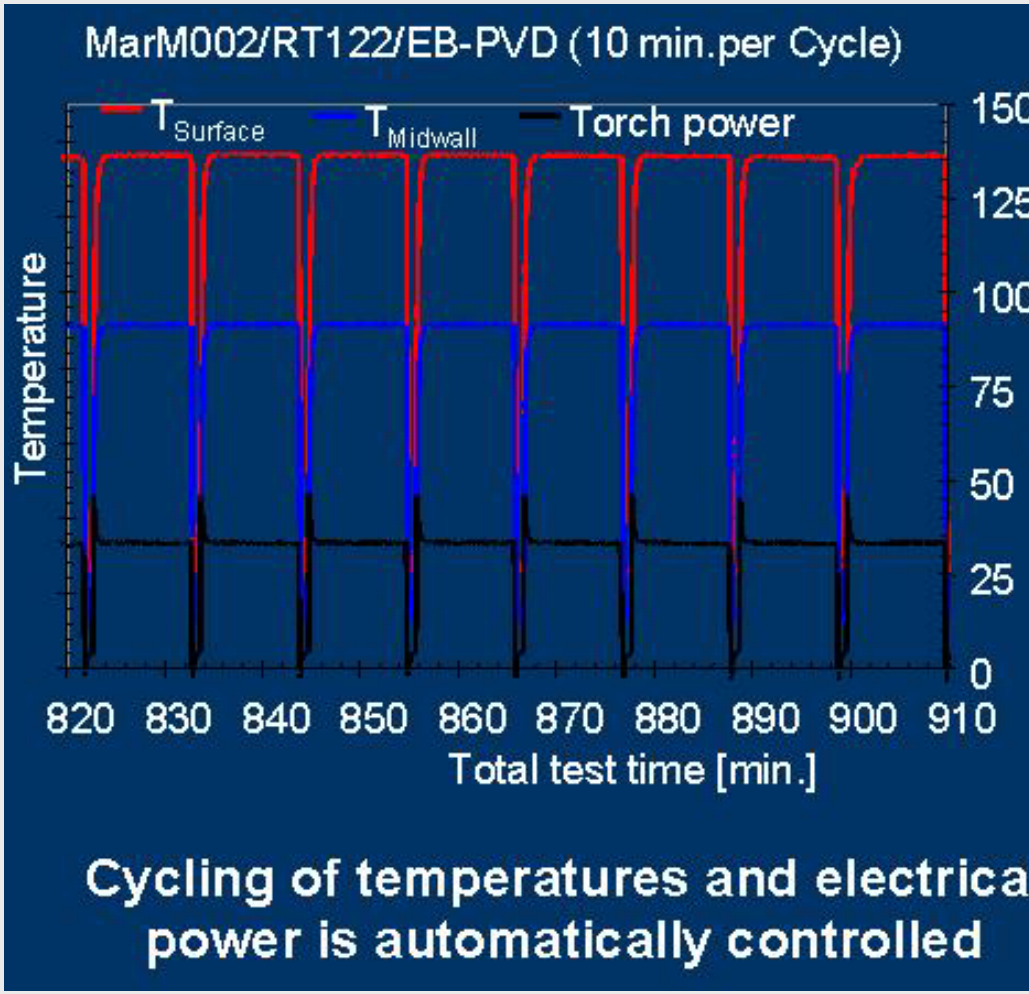
Establish an enabling technology for the futu

Next Generation engines require advanced TBCs with increased temperature capability



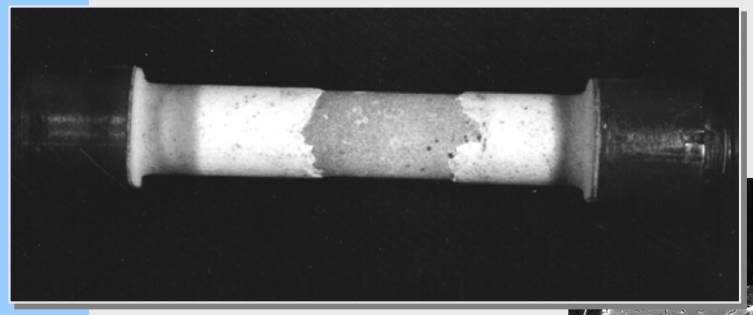
A high heat flux rig, at Waltz Mill, PA, exposes samples to severe thermal gradients

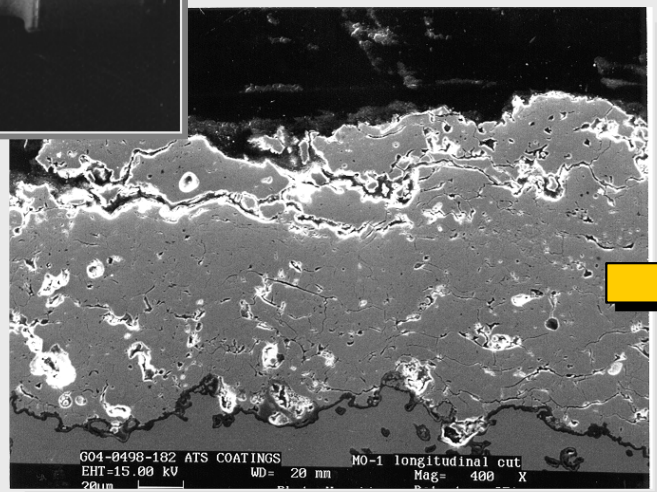


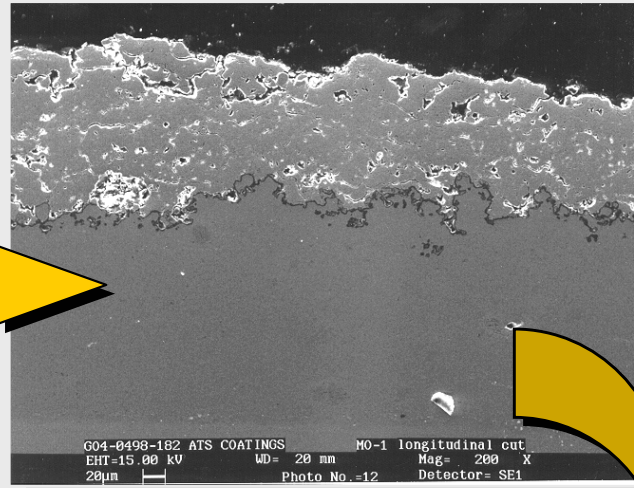


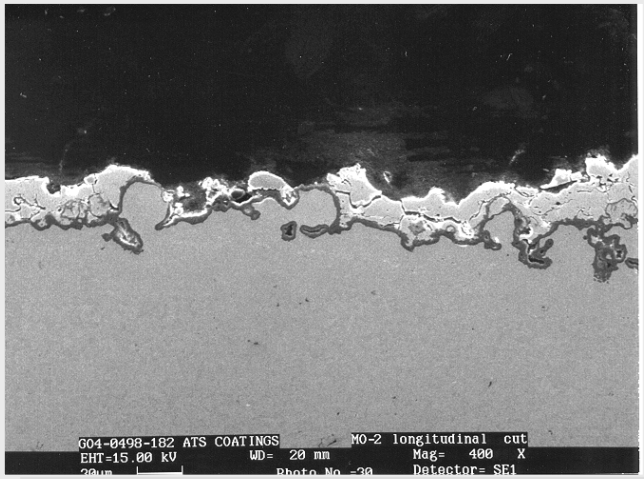
(Westinghouse Plasma Center, PA)

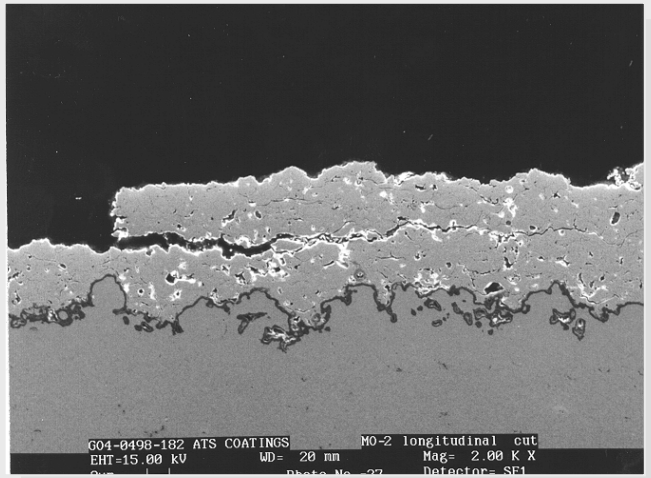
Failure of APS TBC Progresses Layer-by-layer upon exposure to high temperatures





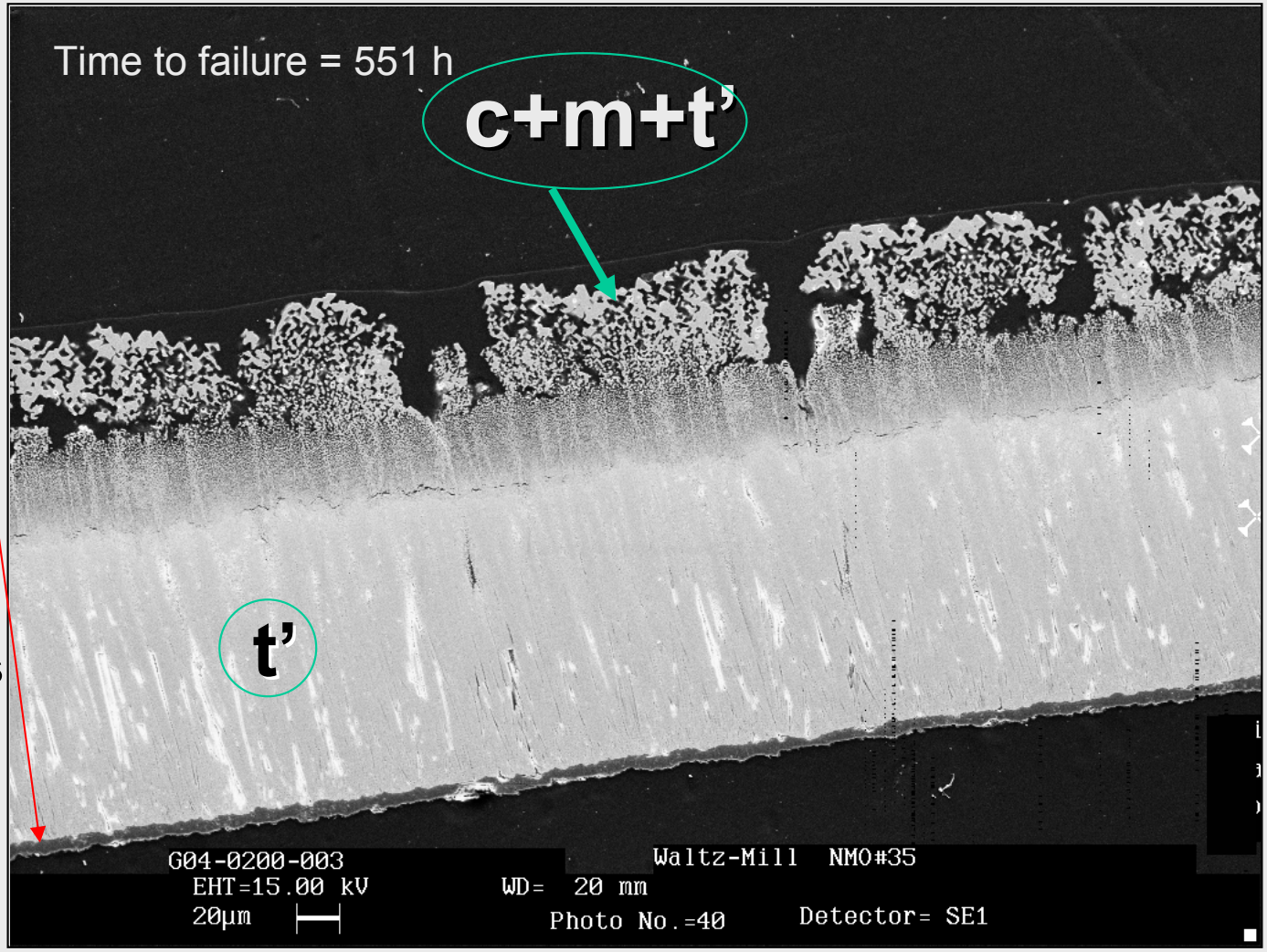




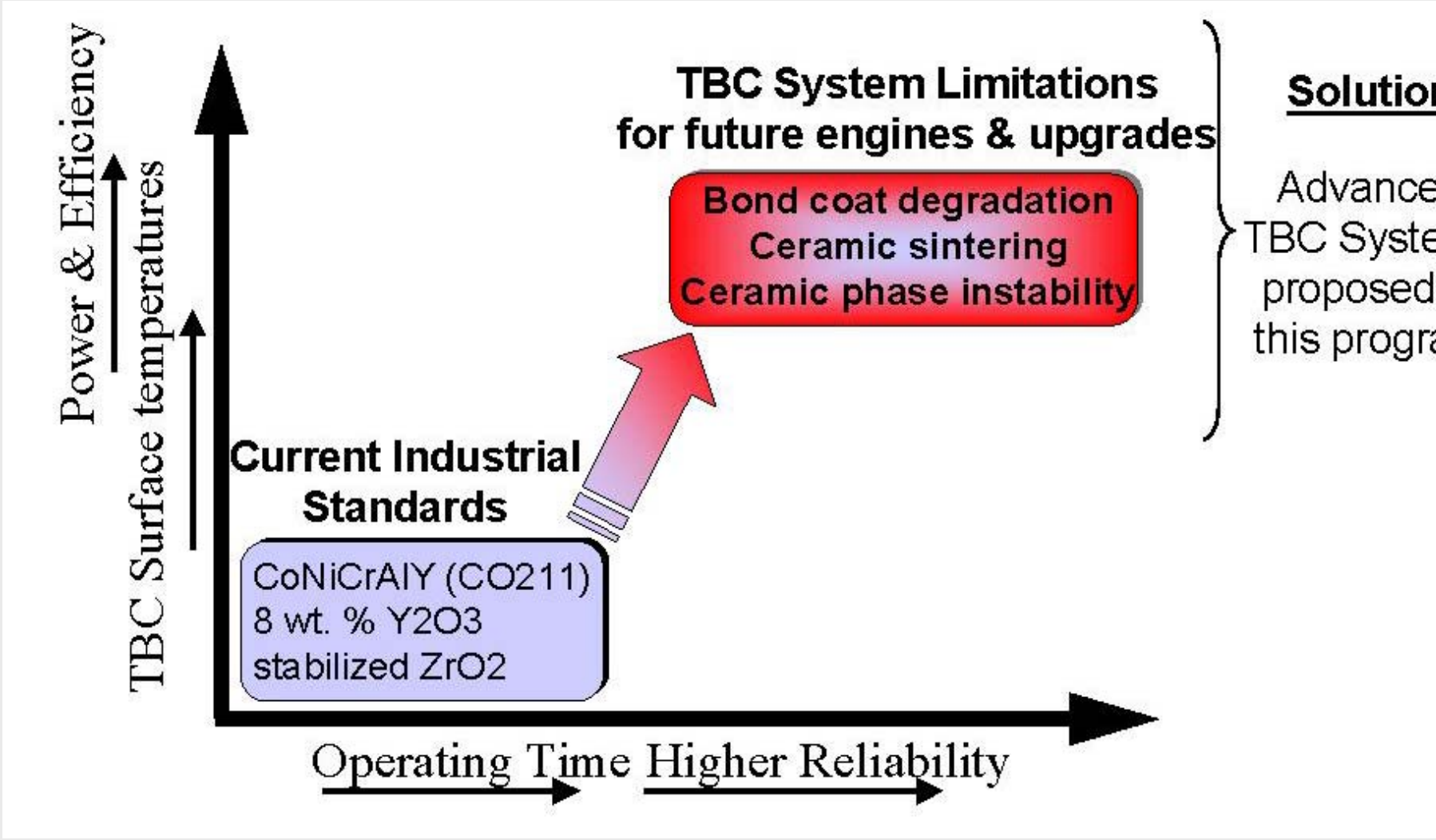


Microturbine and Industrial Gas Turbine Peer

EB-PVD coatings fail due to sintering and show degradation as a result of phase transformation

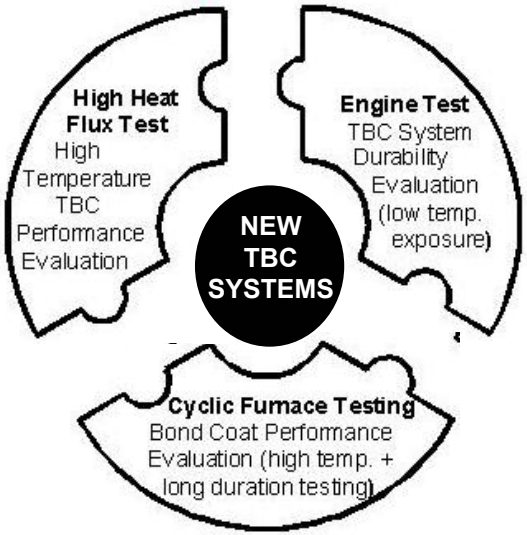


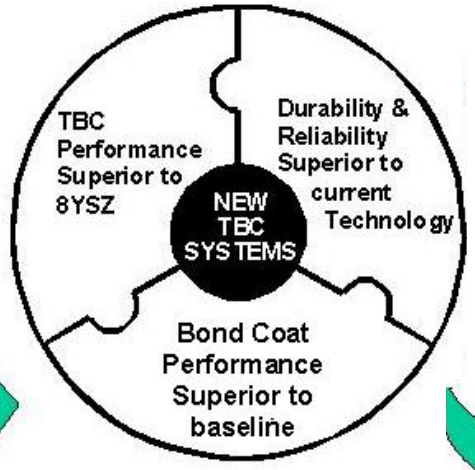
Advanced TBCs can overcome the limitations of the current 8YSZ TBCs



Overview of the technical approach to incorporate advanced technology into our IGT fleet

Low Risk Demonstration





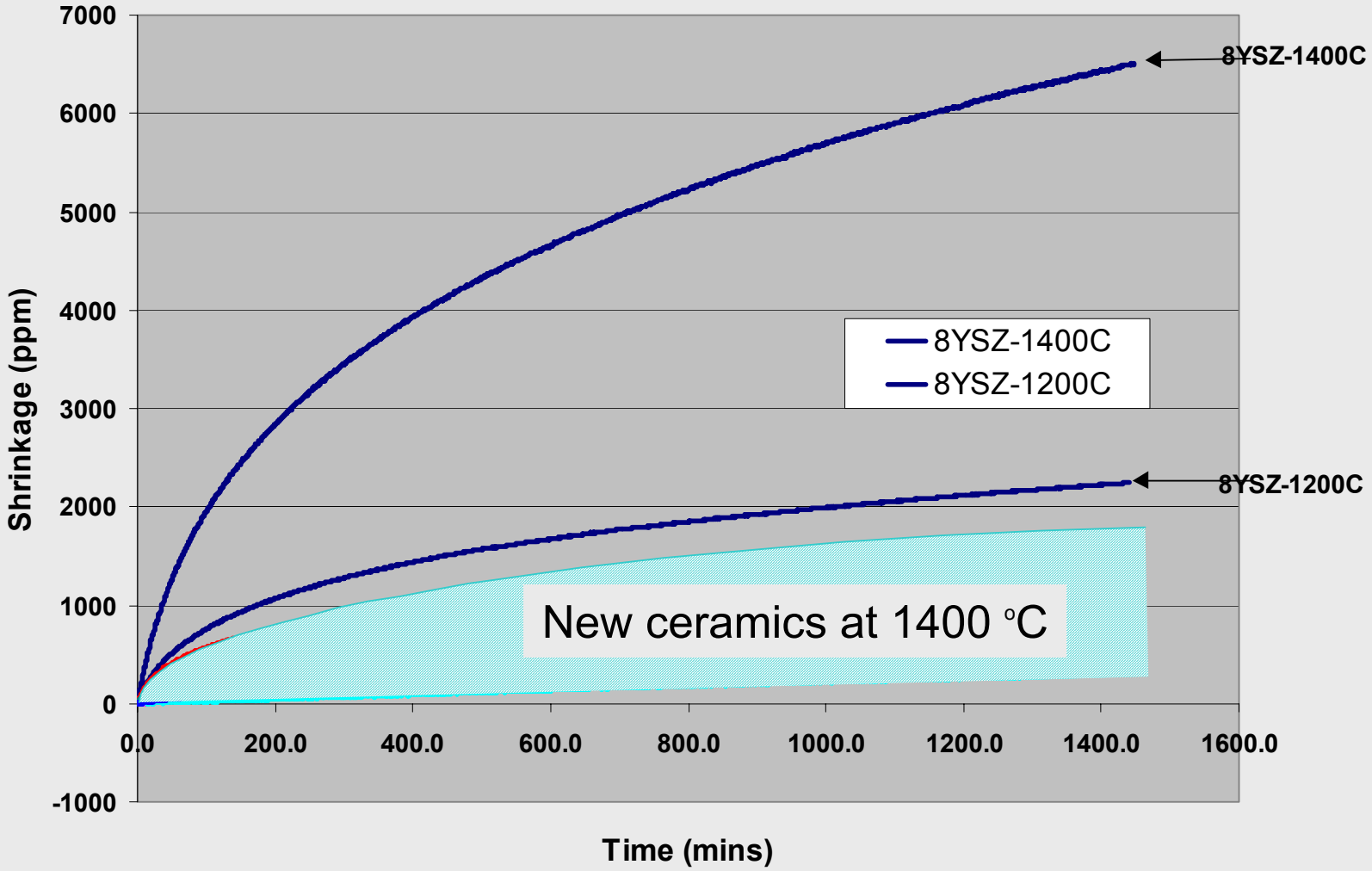
Technology Incorporation into the advanced next generation engines

Continued use at a commercial site with improved reliability

Upgrades and modifications to D5, F, G and V engines

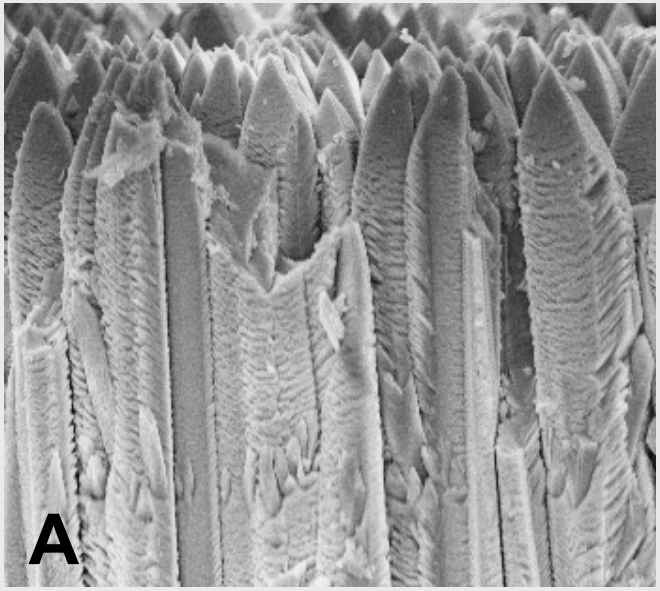
High Pay-off

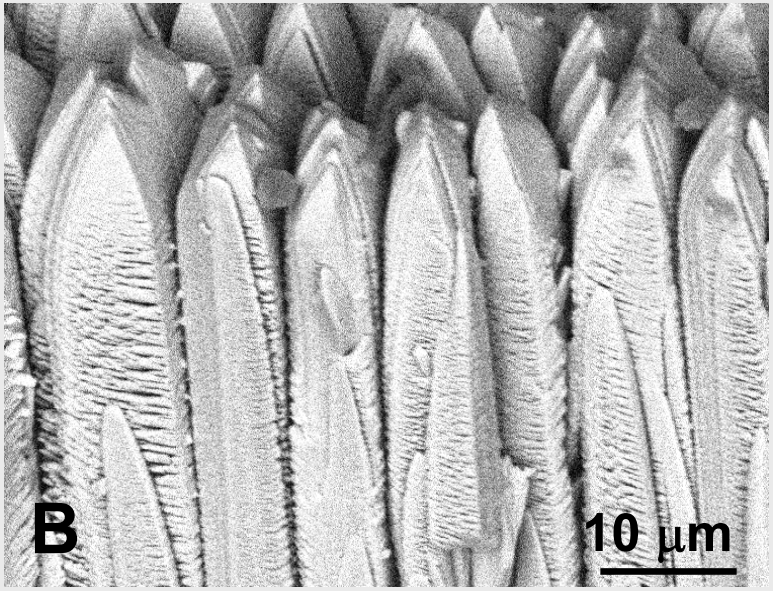
Sintering resistances of new phase stable ceramic compositions were confirmed by dilatometry

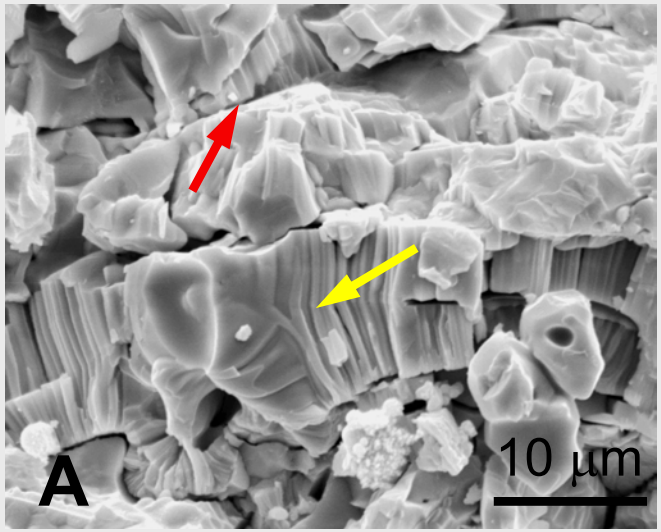


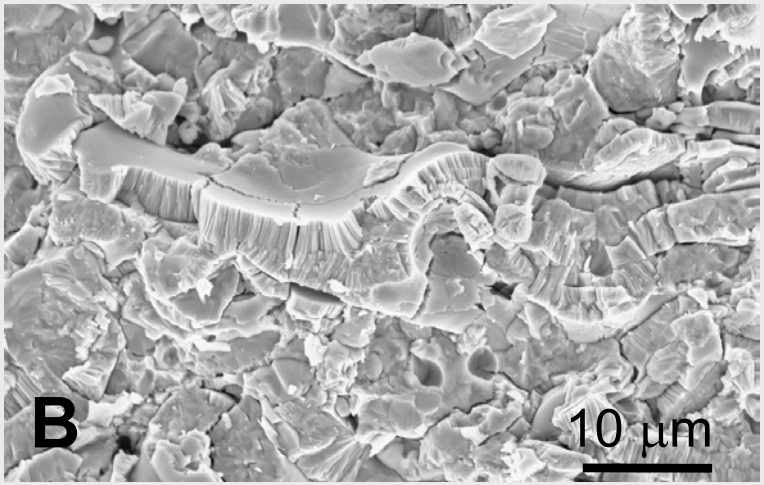
(HTML, Oak Ridge National Laboratory)

New ceramic compositions could be deposited both by APS and PVD with the desired microstructure



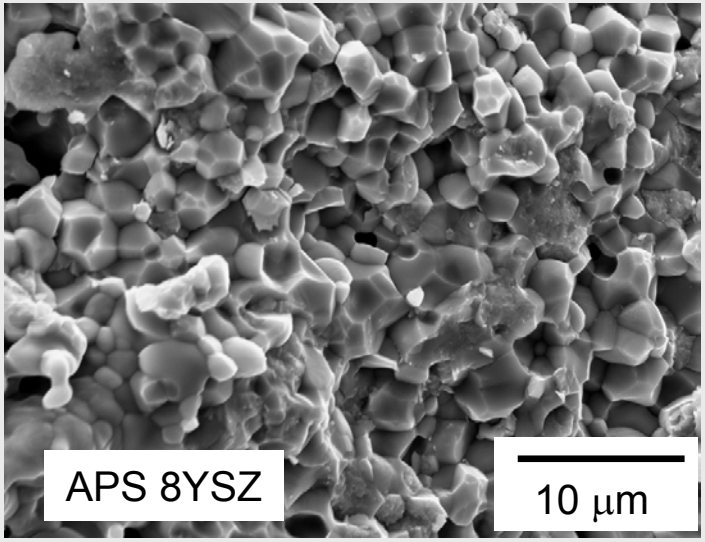


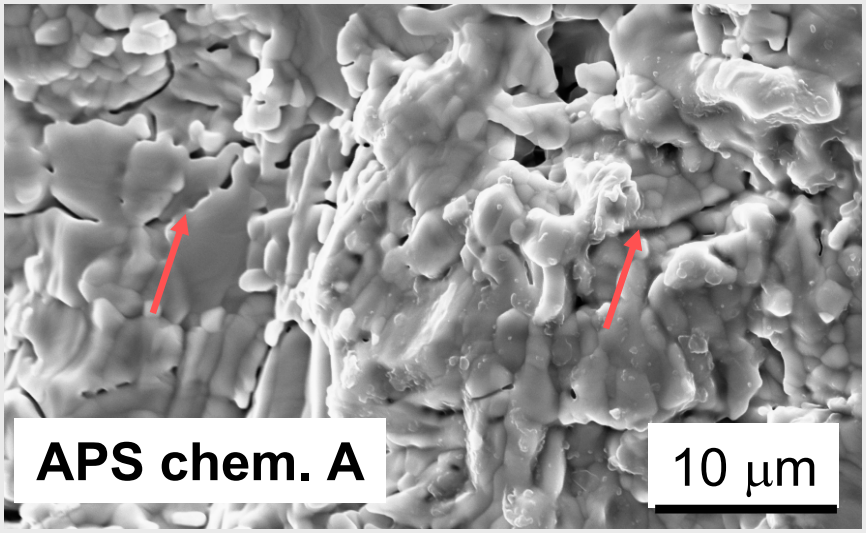


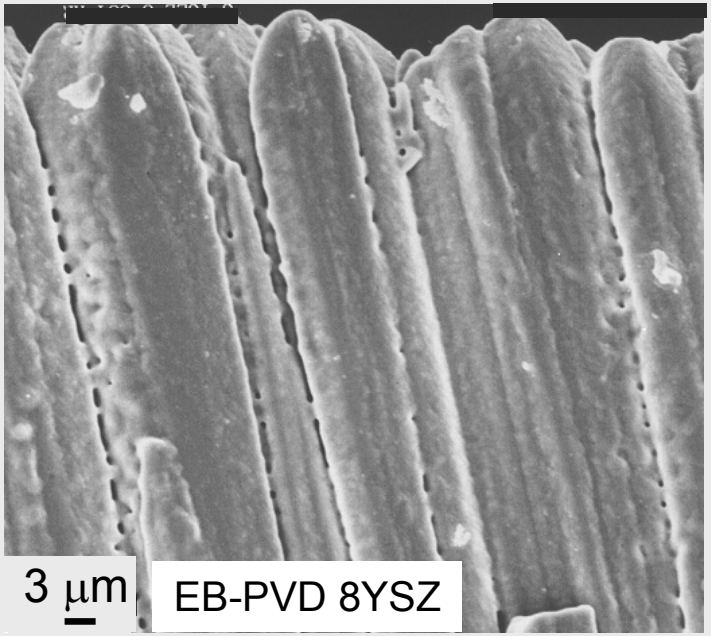


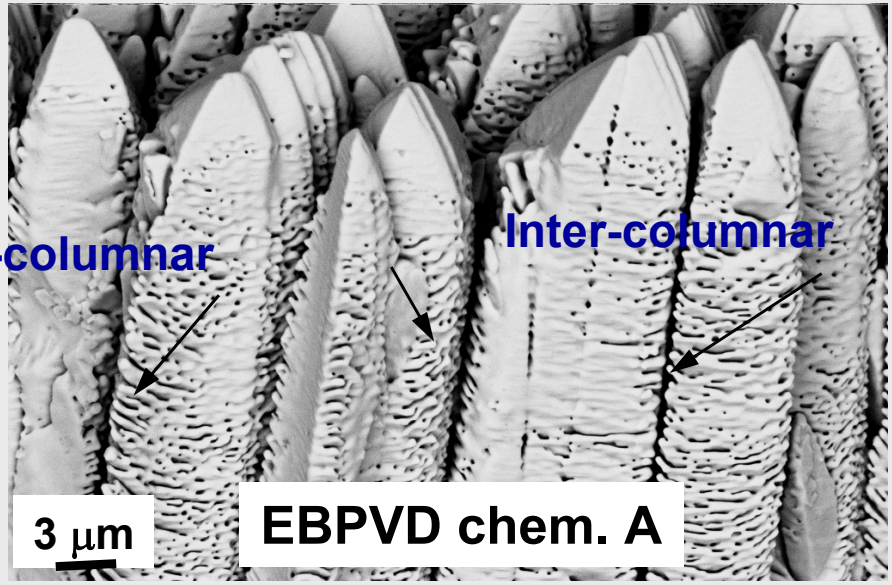
(Howmet Corporation and Praxair Surface Technologies)

Superior sintering resistance, relative to 8YSZ, is observed for all ceramic compositions deposited both by APS and PVD

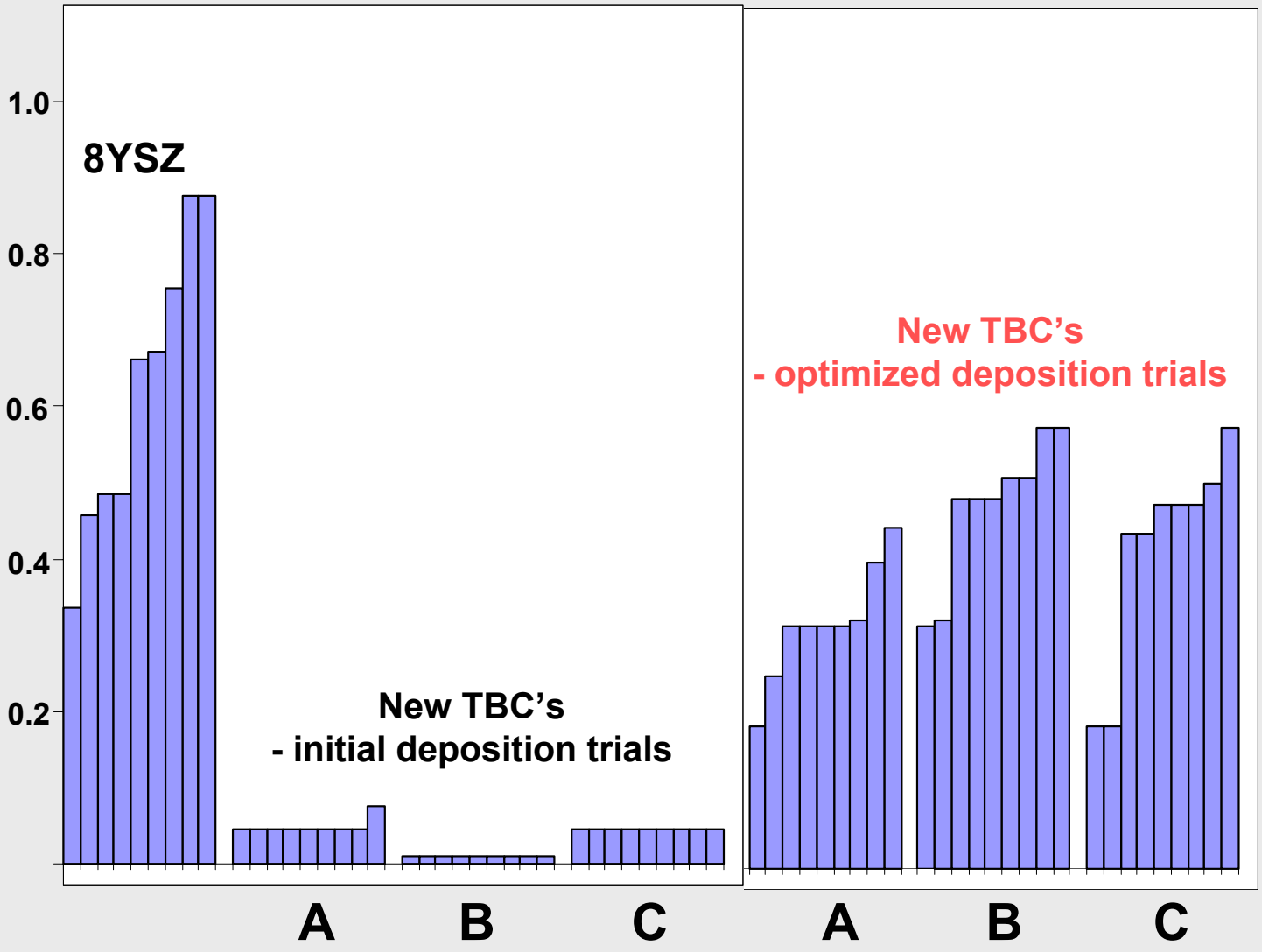






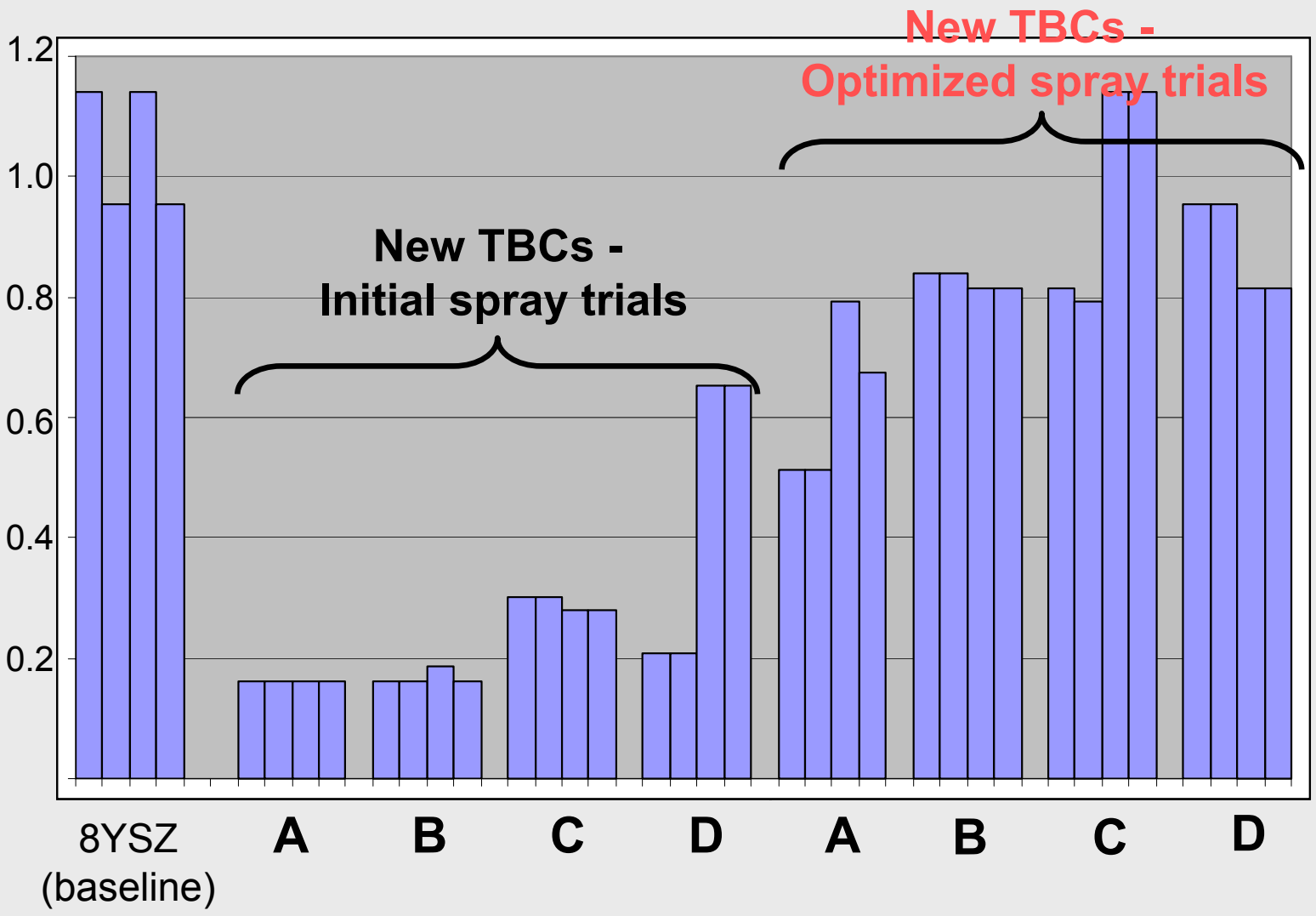


Optimization of the deposition process increased EB-PVD TBC spallation life



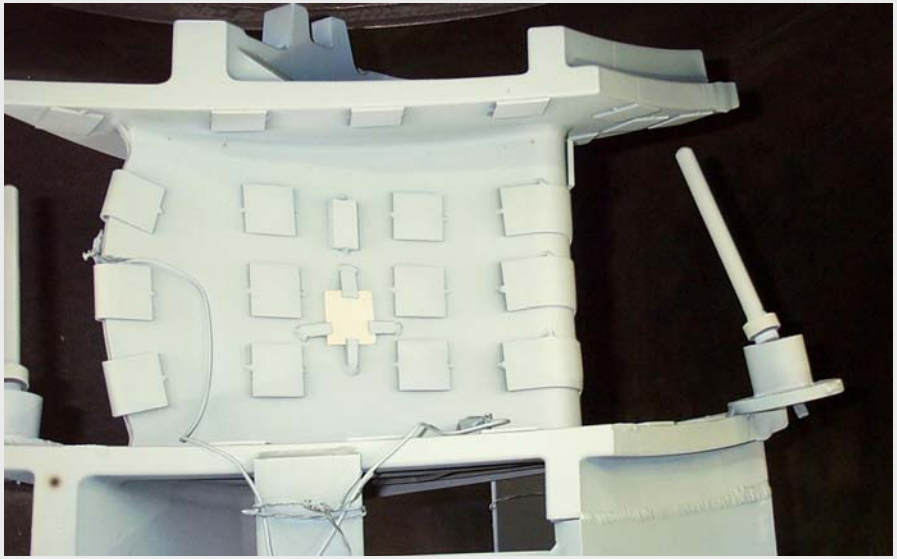
Further optimization is still underway for additional improvements

Optimization of APS parameters also identified a processing window unique to the advanced compositions



Further optimization is still underway for additional improvements

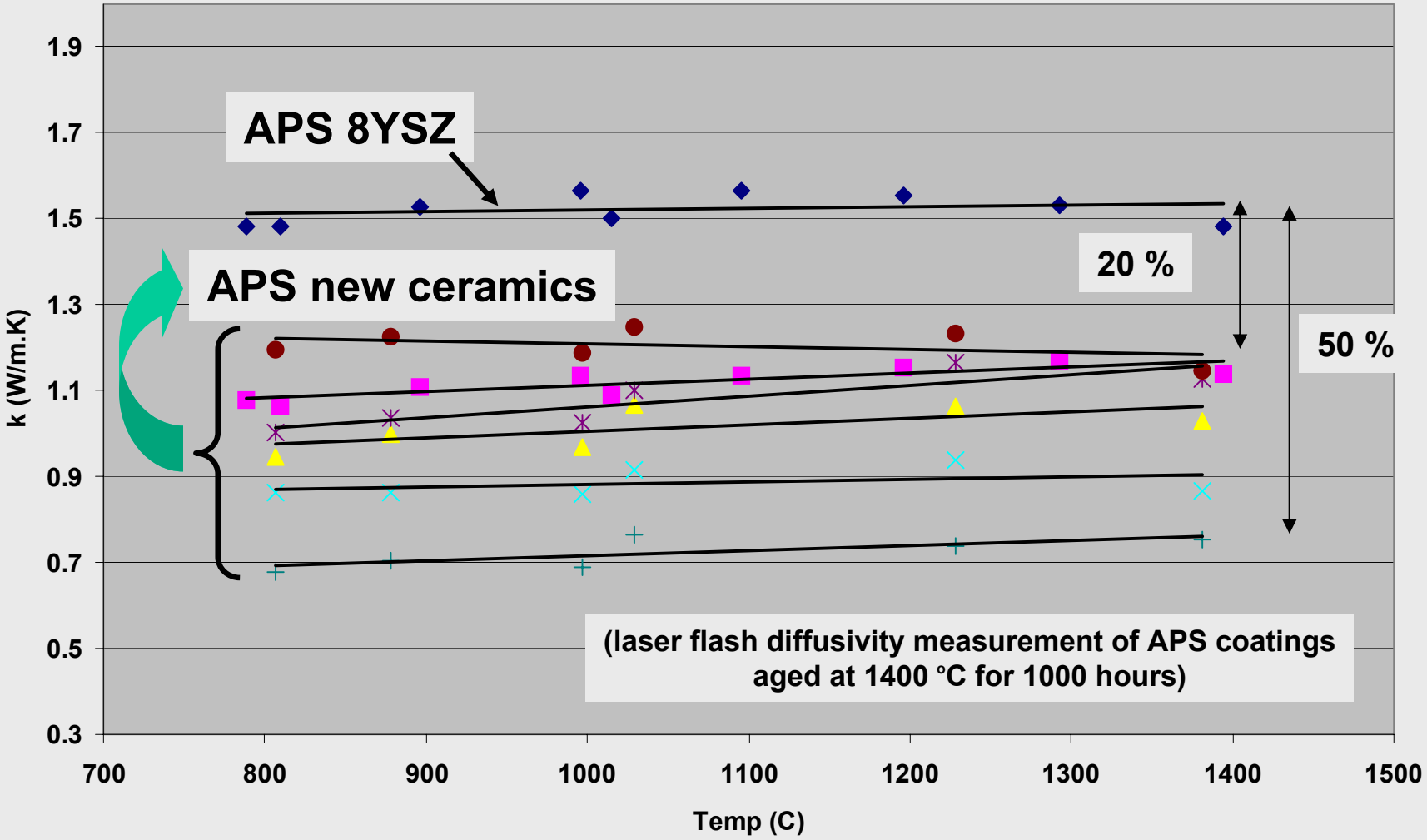
W501 FC blades and vanes have been successfully coated with new TBCs in a production coater



- Thickness and microstructure met product specification requirements
- Consistent composition across airfoil and platform

(Turbine Airfoil and Coating Repair, Middletown, NY)

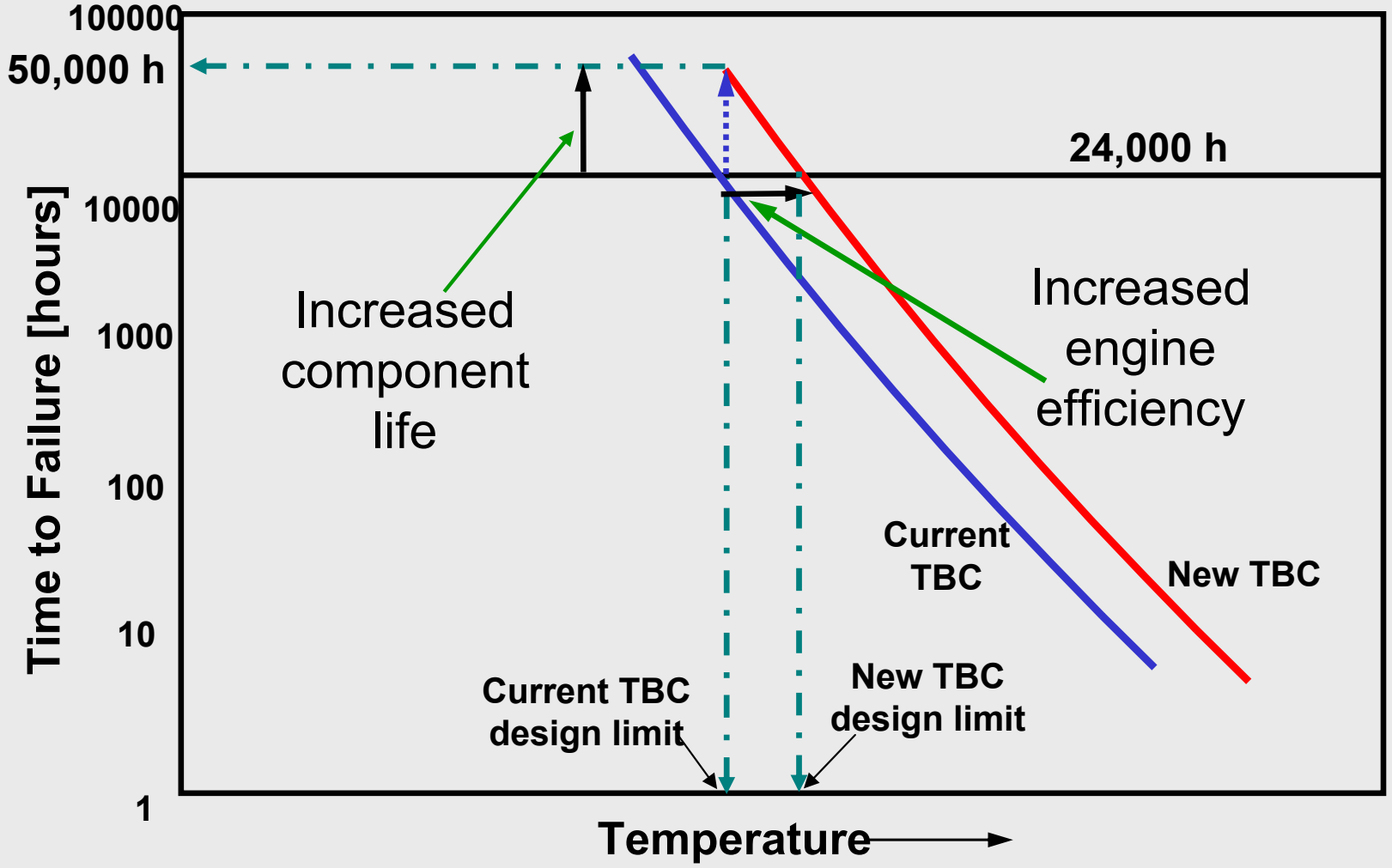
New ceramic compositions have thermal conductivity values 20 % to 50 % lower than APS 8YSZ



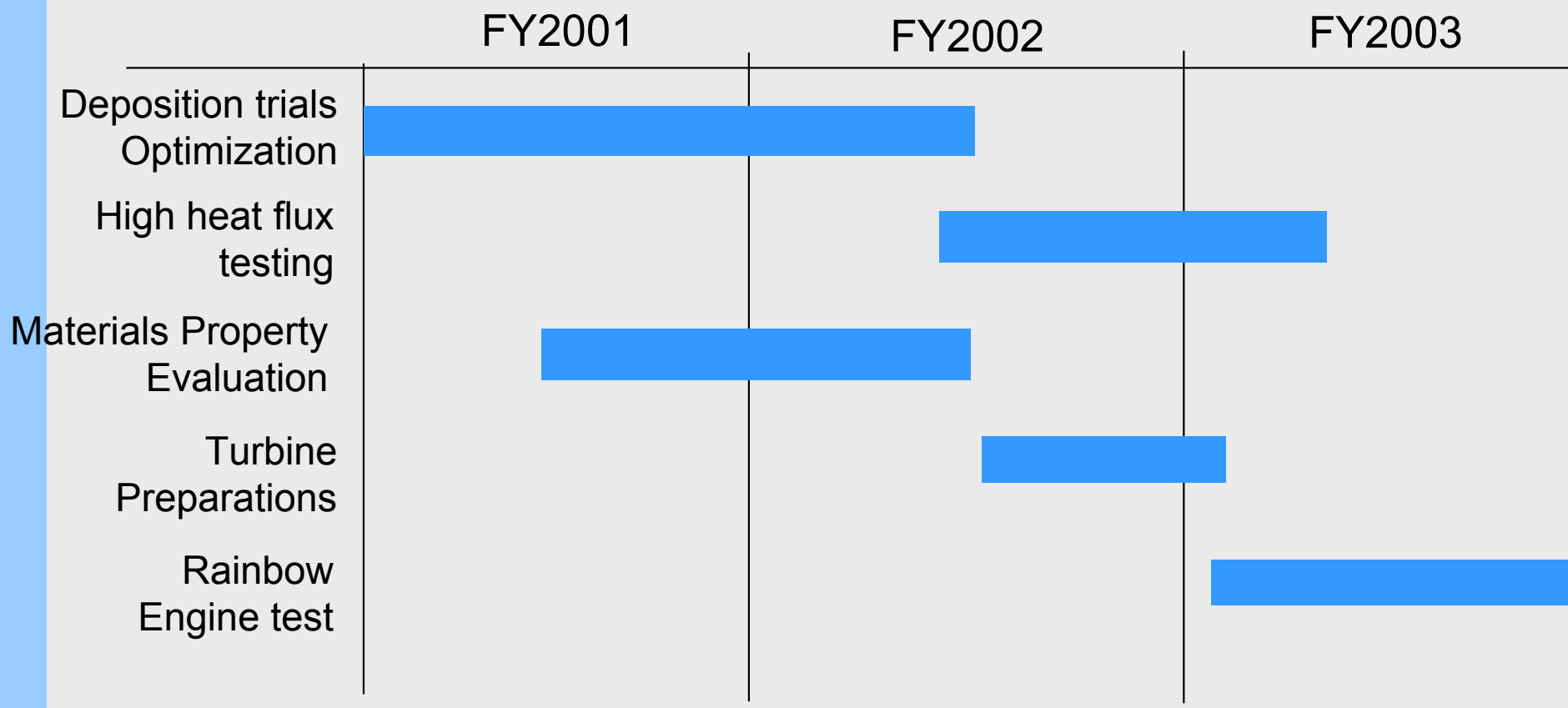
Potential for significant cooling air reduction and increase in engine efficiency

(HTML, Oak Ridge National Laboratory)

Advanced TBCs have a direct impact on engine efficiency and component life



Schedule overview and forward plan to program completion



- High heat flux testing are ongoing and turbine preparations are expected to start by June 2002.
- Rainbow engine test initiation is expected to be in October 2002

Advanced TBCs can significantly impact engine efficiency and performance and component life